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Efficiency and Emission Analysis of Diesel Engine on Blending of Soyabean and Sunflower Oil in Different Proportion

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ABSTRACT

IC engines are primarily used in transportation and power generation. While diesel engines are highly efficient, the emission of pollutant gases, such as carbon monoxide, carbon dioxide, and nitrogen oxides, is a major concern. There are multiple techniques available to reduce the emission of these gases from diesel engines. One effective technique is the utilization of biofuels with certain modifications in the engine. In this research, the performance and emission characteristics of a single-cylinder, four-stroke diesel engine running on diesel fuel blended with soybean and sunflower oils were experimentally investigated. The emission levels of pollutants were measured at an express pollution checking center, providing valuable pollutant data. The combustion of biodiesel blended with soybean and sunflower oils resulted in the generation of HSU percentages. Additionally, the concentrations of CO2, CO, and NOx were calculated using a flue gas analyzer.

Keywords: Diesel Engine, Biodiesel, HSU, blending, pollution.

Introduction

Fossil fuels have served as a temporary energy source for humanity; once depleted, they are gone forever. Alternative non-petroleum fuels offer energy security and environmental advantages. These fuels have been utilized in various forms for over a century. Prior to the widespread use of gasoline as a motor fuel in the late 1800s, vehicles were commonly powered by what are now considered alternative fuels. Rudolf Diesel's first Internal Combustion Engine, showcased at the 1900 Paris World Fair, ran on peanut oil. His vision was to fuel an efficient Internal Combustion Engine with either crude oil or vegetable oil. In the early 1900s, Henry Ford also made a significant contribution by creating one of his first automobiles fueled by ethanol, often referred to as "Farm alcohol" due to its corn-based production.

Bio-diesel, an eco-friendly alternative to diesel, is created from renewable resources such as vegetable oils and animal fats. These natural oils and fats, primarily composed of triglycerides, undergo a process called transesterification to produce bio-diesel. In India, where there is a shortage of edible oils, non-edible oils like Jatropha curcas are considered the most promising source for bio-diesel production.

Bio-diesel

Biodiesel consists of mono alkyl esters produced from vegetable oils, animal or old cooking fats. Coconut biodiesel is fuel alternative produced from soybean oil. Biodiesel contains no petroleum diesel, but it can be blended with petroleum diesel.

Biodiesel is a natural fuel derived from tree-born oils through a chemical process known as Transesterification, which takes place in a Chemical Processing Plant. This process has been used for a long time and is a proven method of converting vegetable oils or fats into Biodiesel (Alkyl Esters of Fatty Acids) and Glycerin, along with some soaps. The transformation of fatty acid chains into Alkyl Esters of the respective fatty acids found in different feed oils, as well as the extraction of glycerol from the Triglyceride molecule in the oils and fats, is where the chemistry lies.

Transesterification Reaction

It is a combination of different fatty acid chains and must be determined based on the oils being used. The subscript 3 signifies the number of moles required to form the methyl esters. This model simply indicates the molar ratios of starting materials and products; however, adjustments may be necessary to achieve a more thorough reaction. Typically, 6 moles of alcohol are utilized for each mole of triglyceride to ensure the reaction progresses in the forward direction. Not all reactions proceed rapidly, and some may require a significant amount of time before reaching equilibrium, where the starting materials and reaction products are present in constant quantities. Reactions can also proceed in the reverse direction (from right to left), so adjustments to the molar ratio, temperature, pressure, and use of a catalyst may be needed to shift the equilibrium towards the desired products.

Literature Review

This article aims to explore the utilization of aluminum oxide (Al_2O_3) in combination with B20 to achieve specific fuel properties based on previous journal research. The objective is to enhance the performance characteristics of diesel engines and improve engine emissions control without requiring any modifications to the engine itself.[1]

A comprehensive analysis was conducted on a diesel engine, operating under various conditions, using different blends of Parinari polyandra biodiesel. The study measured exhaust emissions such as total hydrocarbons, carbon dioxide, carbon monoxide, sulphur dioxide, and nitrogen oxides.[2]

This research focuses on the mechanisms related to the CFP of biodiesel and emphasizes the factors that initiate and control the crystallization process. The study suggests that the CFP of biodiesel fuel can be enhanced through the use of various techniques.[3]

The evaluation of the engine's performance for emulsified fuel and biodiesel obtained from yellow oleander seed oil in a CI engine with single cylinder has been conducted in this study.[4]

The experimental study was carried out following the ESC (European Stationary Cycle - Directive 1999/96/EC) 13-mode. By using biodiesel fuel, the average thermal efficiency is maintained at the level of conventional diesel fuel application. [5]

The diesel engine underwent an experiment where it was tested at various engine loads ranging from zero to full load. The thermal efficiencies of waste cooking-oil biodiesel blends were found to be lower than that of diesel oil. Additionally, the specific fuel consumptions of biodiesel blends were higher compared to diesel fuel. Furthermore, biodiesel blends exhibited higher exhaust gas temperatures in comparison to diesel oil. [6]

The properties of biodiesel derived from Palm Kernel Oil Methyl Ester (PKOME), Jatropha Curcas Methyl Ester (JCME), and Coconut Oil Methyl Ester (COME), as well as their blends, have been analyzed for their suitability in a compression ignition direct injection (CIDI) internal combustion engine. [7]

The global community is currently grappling with energy demand crises, escalating petroleum prices, and the depletion of fossil fuel reserves. Biodiesel, derived from vegetable oils, has emerged as a promising alternative fuel source. While research on blending diesel with single biodiesel has been conducted, limited studies have explored the combination of two different biodiesel blends with diesel, leaving ample room for further exploration in this field. This study presents an experiment involving two biodiesels extracted from pongamia pinnata oil and mustard oil, which were then blended with diesel at varying ratios. [8]

With the depletion of fossil fuels and the increase in greenhouse gases, the utilization of biodiesel has emerged. Biodiesel is a renewable and clean-burning diesel fuel that can be derived from vegetable oils. This particular project focuses on examining the emission and performance characteristics of a diesel engine using blends of Neem oil as biodiesel. The Neem oil is transformed into biodiesel through the transesterification process, with the addition of 1% v/v H_2SO_4. [9]

The study examined the performance and emissions of a single cylinder four-stroke variable compression multi-fuel engine running on blends of Karanja and diesel at 20%, 25%, and 30%, in comparison to standard diesel. Experiments were carried out at compression ratios of 15:1, 16:1, 17:1, and 18:1. [10]

The study showcases the performance of biodiesel blends in a single-cylinder water-cooled diesel engine. All tests were conducted at a constant speed of 1500 rpm, with biodiesel blends ranging from B10 to B100. The engine featured a variable compression ratio (VCR) mechanism. In the case of 100% Jatropha biodiesel, fuel consumption was 15% higher compared to diesel. [11]

A study [12] revealed that methyl ester of coconut oil can partially substitute diesel fuel in existing conventional diesel engines without requiring major modifications to engine components. Blends of up to 40% methyl ester of coconut oil showed engine performance comparable to that of diesel-fueled engines, with only minor differences.

Experimental Setup

The experiment was performed in a Bio-Diesel generating setup with a capacity of one hundred liters per day. This setup is designed to produce Bio-Diesel from various oil seeds. Additionally, the Thermal Engineering Lab of the Mechanical Engineering Department has a single cylinder 4-stroke diesel engine for conducting experimental work to test the performance of Bio-Diesel. This chapter provides a detailed description of the procedure for making biodiesel. It also includes the complete technical specifications of the CI engine test kit used for performance testing. Furthermore, the chapter records the procedure followed for conducting the experiments.

Procedure Preparation of Biodiesel

(i) Biodiesel preparation from palm and soya bean oil:

Since, waste vegetable cooking oil is a more economical source of the fuel than other sources, it is considered as a source of the biodiesel in this study.

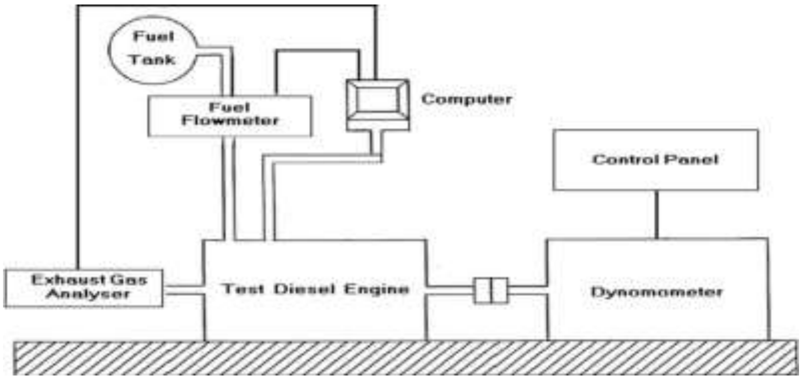
a. Palm oil

b. Soya bean oil

In this research, biodiesel will be produced by a transesterification process catalyzed by KOH (as Alkali catalyst) and methanol (as alcohol).

(ii) Blend preparation at different proportion:

Samples of palm oil biodiesel and mineral diesel were prepared using an electrical magnetic stirrer. To begin, palm oil biodiesel was added to petroleum diesel at a low stirring rate. The mixture was stirred continuously for 20 minutes and then left for 30 minutes at room temperature to reach equilibrium before any tests were conducted. Additionally, five biodiesel diesel blends were prepared by blending palm oil biodiesel at 10%, 20%, 30%, 40%, and 50% by volume with mineral diesel.



Blend preparation set up

(iii) Fuel property measurements

The properties of the biodiesel and diesel fuel analysis in accordance with the ASTM D6751 standards in a testing laboratory.

Biodiesel Sample

Single cylinder 4 Stroke Diesel (CI) Engine Experimental Set-up

Details along with technical specifications of this kit being discussed as below.

Experimental Setup of Diesel Engine

Technical Specification

A) DIESEL ENGINE

MAKE: - Kirloskar Oil Engine, Pune.

MODEL: - SV1

TYPE: - Vertical, Totally Enclosed, Compression Ignition Four Stroke Cycle, Water cooled engine.

NO. Of CYLINDER: - ONE

BORE: - 87.5 mm

STROKE: - 110 mm

CUBIC CAPACITY: - 662 CC

COMPRESSION RATIO: - 16.5: 1

RPM: - 1800

RATE OF OUTPUT: - 8 HP

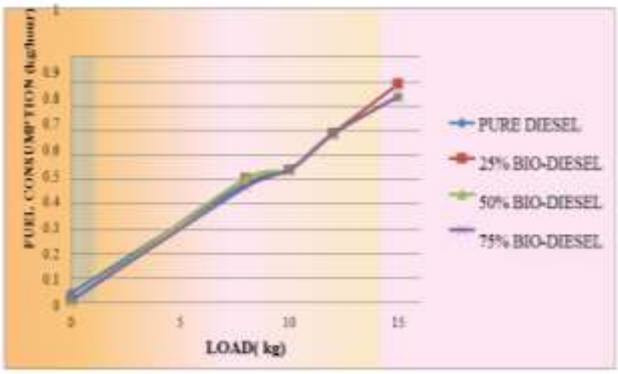
Test Parameters

These are to be entered every time engine testing has to be done. First load is selected and set then its results like temperature, fuel consumption ration, RPM etc for corresponding load to be entered Manually/Automatically.

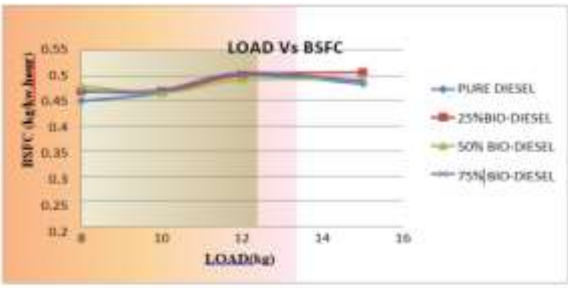
Results and Discussions

The single cylinder 4-stroke diesel engine underwent multiple experimental trials, with data being gathered at various loads for pure diesel as well as different blends of diesel and biodiesel. The collected data was then compiled and presented in the graphs displayed below.

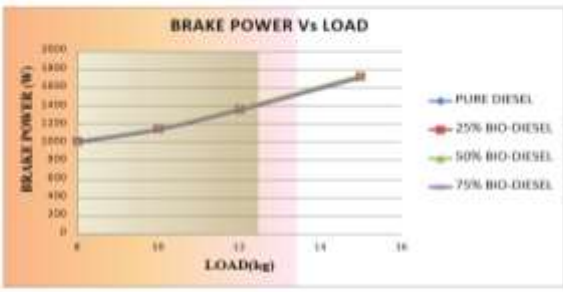
Variation of speed with load for pure diesel and diesel blends with biodiesel (Soyabean and Sunflower)



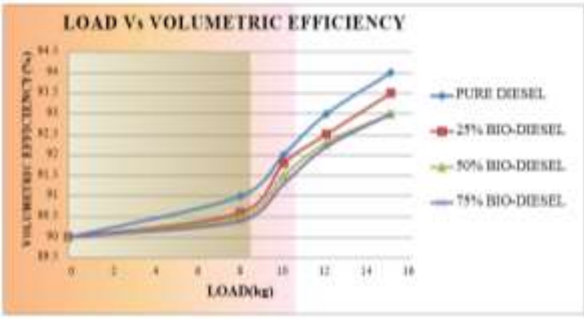
Variation of fuel consumption with load for pure diesel and soyabean diesel blends with biodiesel

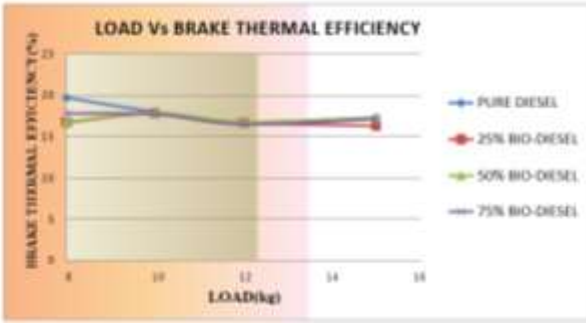


Variation of BSFC, with load for pure diesel and soyabean diesel blends with biodiesel



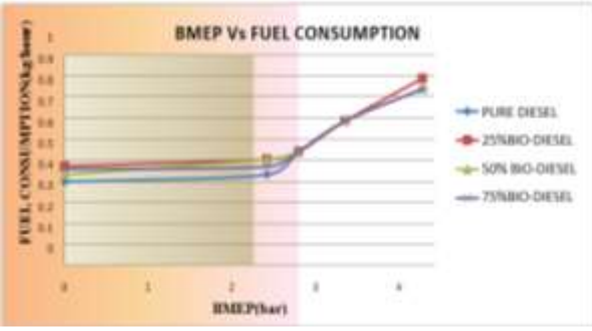
Variation of Brake power with load for pure diesel and soyabean diesel blends with biodiesel

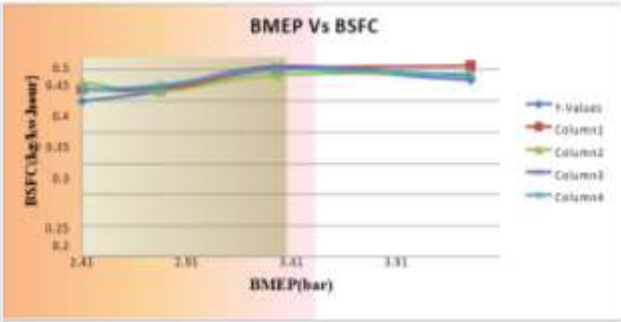




Variation of brake thermal efficiency with load for pure diesel and soyabean diesel blends with biodiesel

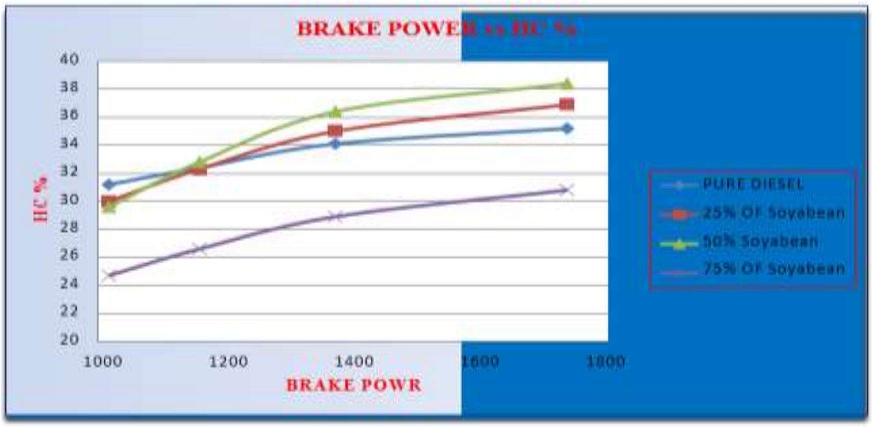
Variation of volumetric efficiency with load for pure diesel and soyabean diesel blends with biodiesel





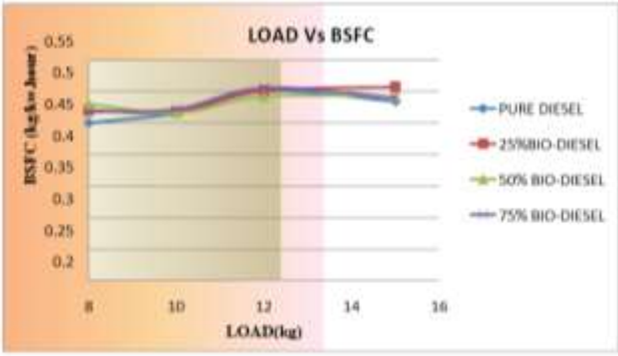
Variation of fuel consumption with BMEP for pure diesel and soyabean diesel blends with biodiesel

Variation of BSFC with BMEP for pure diesel and soyabean diesel blends with biodiesel

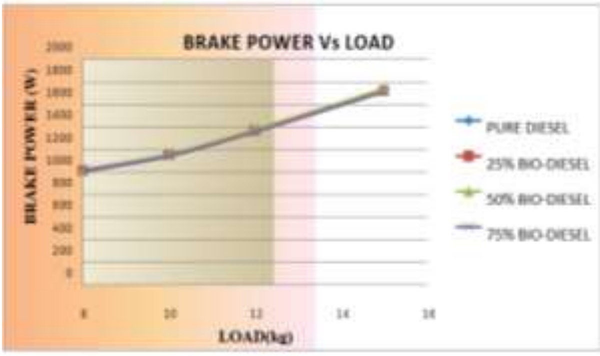


Brake power Vs (HC %) in case of soyabean biodiesel blends

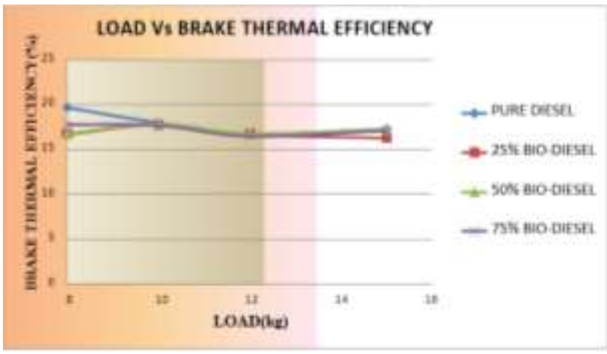
Graphs of sunflower biodiesel



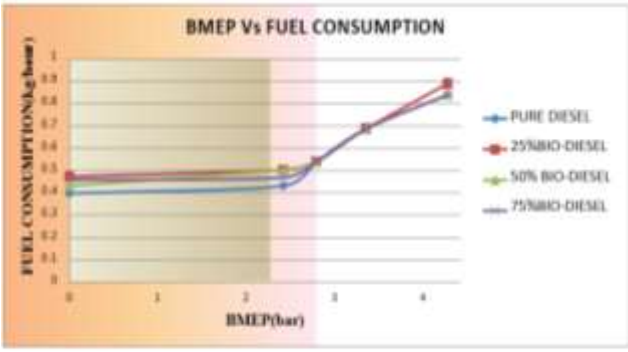
Variation of BSFC, with load for pure diesel and sunflower diesel blends with biodiesel



Variation of Brake power with load for pure diesel and sunflower diesel blends with biodiesel



Variation of brake thermal efficiency with load for pure diesel and sunflower diesel blends with biodiesel



Variation of fuel consumption with BMEP for pure diesel and sunflower diesel

Brake power Vs (HC %) in case of sunflower biodiesel blends blends with biodiesel

Analysis of emission characteristics

Single Cylinder Four Stroke Diesel Engine

Sunflower used as Bio-Diesel

Ist Proportion – 75% Diesel & 25% Biodiesel

S.No.	Load	Fuel	Mixture	Time
1	0 kg	15ml	5ml	60 sec.

On burning this above proportion, the emitted pollutants will be measured in Express Pollution Checking Center. Following data was provided as a resultant:

S.No.	Km-1	HSU%
1	0.62	23.4
2	0.64	24.2
3	0.71	26.3
4	0.72	26.7
5	1.83	54.6
Mean	1.63	50.4

IInd Proportion – 50% Diesel and 50% Biodiesel

S.No.	Load	Fuel	Mixture	Time
1	0 kg	10ml	10ml	60 sec.

On burning this above proportion, the emitted pollutants will be measured in Express Pollution Checking Center. Following data was provided as a resultant:

S.No.	Km-1	HSU%
1	0.90	32.3
2	0.66	24.8
3	0.73	26.9
4	0.77	28.4
Mean	0.76	28.1

IIIrd Proportion – 25% Diesel and 75% Biodiesel

S.No.	Load	Fuel	Mixture	Time
1	0 kg	5ml	15ml	60 sec.

On burning this above proportion, the emitted pollutants will be measured in Express Pollution Checking Center. Following data was provided as a resultant

S.No.	Km-1	HSU%
1	1.82	50.4
2	0.73	26.7
3	0.64	23.9
4	0.74	28.3
5	0.64	32.3
Mean	0.85	29.3

Soyabean used as Bio-Diesel

Ist Proportion – 75% Diesel & 25% Biodiesel

S.No.	Load	Fuel	Mixture	Time
1	0 kg	15ml	5ml	60 sec.

On burning this above proportion, the emitted pollutants will be measured in Express Pollution Checking Center. Following data was provided as a resultant:

S.No.	Km-1	HSU%
1	2.64	67.8
2	0.83	30.0
3	0.90	32.3
4	1.00	35.0
5	1.07	36.9
Mean	0.95	33.5

IInd Proportion – 50% Diesel and 50% Biodiesel

S.No.	Load	Fuel	Mixture	Time
1	0 kg	10ml	10ml	60 sec.

On burning this above proportion, the emitted pollutants will be measured in Express Pollution Checking Center. Following data was provided as a resultant

S.No.	Km-1	HSU%
1	1.80	54.0
2	1.65	50.9
3	1.69	51.7
4	1.63	50.05
Mean	1.69	51.7

IIIrd Proportion – 25% Diesel and 75% Biodiesel

S.No.	Load	Fuel	Mixture	Time
1	0 kg	5ml	15ml	60 sec.

On burning this above proportion, the emitted pollutants will be measured in Express Pollution Checking Center. Following data was provided as a resultant:

S.No.	Km-1	HSU%
1	1.67	51.3
2	0.66	24.7
3	0.72	26.6
4	0.79	28.9
5	0.85	30.8
Mean	0.75	27.7

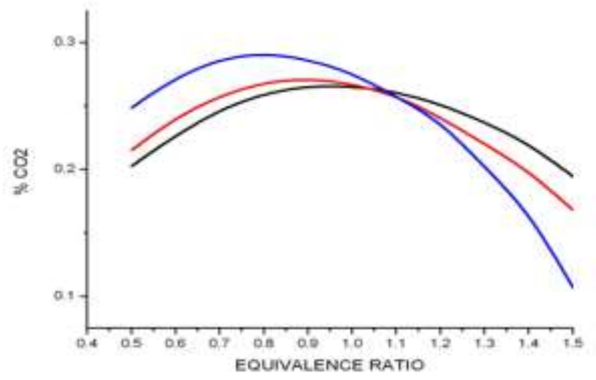
From the above data, it was confirmed that the pollutant gaseous emission was well under the criteria of Bharat Standard IV.

From the above table it was also confirmed that the HSU percentage of Soyabean blended diesel of proportion 25% Diesel and 75% Biodiesel is 27.7 which is very less as compared with other. So from pollution point of view it was a favourable biodiesel mixture which will protect our environment.

With the help of Flue Gas Analyser, the emited gas comes from the burning of biodiesel is measured:

Carbon di Oxide

An increase in the equivalence ratio results in a corresponding increase in the CO_2 value due to the completion of combustion. The oxidation of CO to CO_2 happens through recombination reactions between CO and different oxidants. When the equivalence ratio exceeds 1, the amount of air is reduced, leading to an insufficient amount for the formation of CO_2, thus causing a decrease in the amount of CO_2.



---- 75% Diesel and 25% Biodiesel

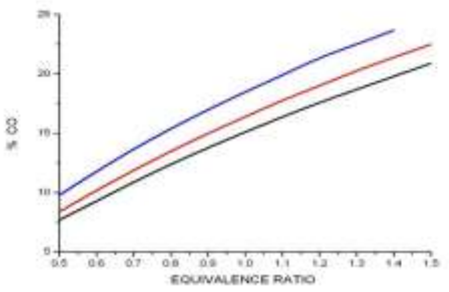
---- 50% Diesel and 50% Biodiesel

---- 25% Diesel and 75% Biodiesel

Variation of percentage of CO_2 with equivalence ratio

Carbon mono oxide:

Carbon monoxide (CO) is a byproduct that occurs during the combustion process of hydrocarbons. It is primarily formed when combustion is incomplete, which can be influenced by factors such as insufficient oxidants, temperature, and residence time. When fuel-rich mixtures are burned, higher levels of CO emissions are typically produced. However, diesel combustion, which is lean and has an ample air supply, results in very low CO emissions.



---- 75% Diesel and 25% Biodiesel

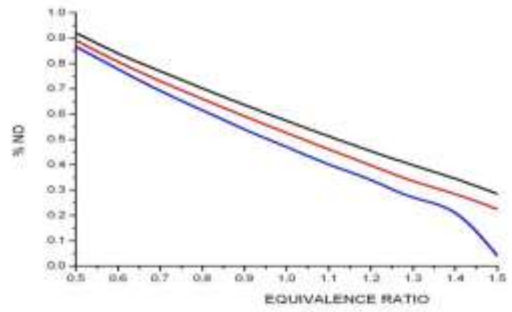
---- 50% Diesel and 50% Biodiesel

---- 25% Diesel and 75% Biodiesel

Variation of percentage of CO with equivalence ratio

Nitrous oxide:

The production of NO is heavily reliant on the combustion temperature and the level of oxygen in the engine. When the equivalence ratio is below 1, there is an ample amount of air in the engine for nitrogen to react with oxygen and produce NO. However, when the equivalence ratio surpasses 1, there is a deficiency of air, leading to a reduction in NO levels. Diesel has a higher combustion temperature than biodiesel, resulting in a greater quantity of exhaust NO emissions from Diesel.



---- 75% Diesel and 25% Biodiesel

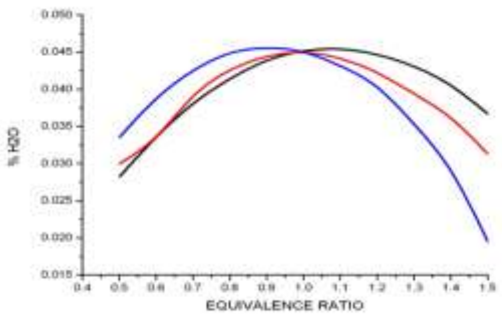
---- 50% Diesel and 50% Biodiesel

---- 25% Diesel and 75% Biodiesel

Variation of percentage of NO with equivalence ratio

Water vapours

In the presence of a lean mixture of fuel and air, water vapor formation is minimal due to the cooling effect of air. However, as the equivalence ratio is raised, the production of water vapor increases and reaches its peak at an equivalence ratio of 1. This is because the temperature is at its highest at this point. Subsequently, the formation of water vapor begins to decrease as the dissociation effect becomes more dominant.



---- 75% Diesel and 25% Biodiesel

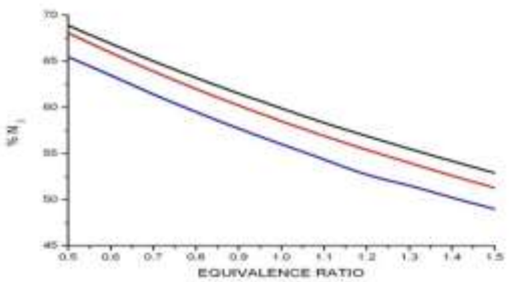
---- 50% Diesel and 50% Biodiesel

---- 25% Diesel and 75% Biodiesel

Variation of percentage of H2O with equivalence ratio

Nitrogen

In the presence of a lean mixture of fuel and air, water vapor formation is minimal due to the cooling effect of air. However, as the equivalence ratio is raised, the production of water vapor increases and reaches its peak at an equivalence ratio of 1. This is because the temperature is at its highest at this point. Subsequently, the formation of water vapor begins to decrease as the dissociation effect becomes more dominant.



---- 75% Diesel and 25% Biodiesel

---- 50% Diesel and 50% Biodiesel

---- 25% Diesel and 75% Biodiesel

Variation of percentage of Nitrogen with equivalence ratio

Conclusion

In the current study, it was observed that the emissions for all three blends were lower compared to pure diesel. However, existing literature suggests that the combustion of biodiesel leads to higher NOx emissions. The current model calculates the formation of NO based on temperature, and it is evident that biodiesel combustion results in higher NO emissions due to factors such as higher bulk modulus and increased fuel consumption caused by higher densities.

Furthermore, the results also confirmed that the HSU percentage of the Soyabean blended diesel, with a proportion of 25% Diesel and 75% Biodiesel, is 27.7, which is significantly lower compared to other blends. From an environmental perspective, this biodiesel mixture proves to be favorable in terms of pollution control and protecting our environment.

References

[1] Performance and emission analysis of di diesel engine fuelled by biodiesel with Al2O3 nano additives. volume 47, part 1, 2021

[2]Exhaust emissions and engine performance analysis of a marine diesel engine fuelledwith parinari polyandra biodiesel–diesel blends; nov. 2020

[3]A mini review on the cold flow properties of biodiesel and its blends; dec. 2020

[4]Performance of diesel engine using biodiesel and hybrid biofuel. the iup journal of mechanical engineering, vol. xii, no. 3, august 2019, pp. 71-78

[5]A diesel engine performance measurement with diesel fuel and biodiesel 2019.

[6]Study of the performance and emission characteristics of di diesel engine fuelled with biodiesel-diesel blends 2019.

[7] Performance evaluation of biodiesel-biodiesel blends in a dedicated cidi engine 2018.

[8] Ministry of petroleum and natural gas gazette dated sept 12th 2003, part 1.page230.

[9] Mathur and sharma, a course in internal combustion engines. 2005 page 517.

[10]K. srithar, k. arun balasubramanian; experimental investigations on mixing of two biodiesels blended with diesel as alternative fuel for diesel engines ; engineering sciences (2017) 29, 50–56.

[11] Jayashri n. nair, ajay kumar kaviti; analysis of performance and emission on compression ignition engine fuelled with blends of neem biodiesel; egyptian journal of petroleum (2017) 26, 927–931.

[12]K. sivaramakrishnan; investigation on performance and emission characteristics of a variable compression multi fuel engine fuelled with karanja biodiesel–diesel blend; egyptian journal of petroleum xxx (2017)

[13]Amar pandhare and atul padalkar; investigations on performance and emission characteristics of diesel engine with biodiesel (jatropha oil) and its blends; journal of renewable energy volume 2013, article id 163829, 11 pages

[14]Comparison of pure plant oil and bio diesel as fuel" by prof. e. schrimpff,fachhochschule weihenstephan, university of applied sciences, "the largest 'green' university of applied sciences in germany" 2005.

[15] Marine biodiesel in recreational boats, randall von wedel, ph.dcyto culture international inc, point richmond, ca second edition april 22, 1999.

[16]R.j. crookes, comparative bio-fuel performance in internal combustion engines science

direct, elsvier bio-mass & bio- energy international journal .feb .2006 page no.1 to 7

[17]Charles l peterson and daryle reecee, production and testing of ethyl and methyl esters, department of biological and agricultural engineering, university of idaho, moscow, dec 1994.